AD-A045 702 ITT GILFILLAN VAN NUYS CA F/G 17/9
UNATTENDED/MINIMALLY ATTENDED RADAR STUDY. VOLUME I. EXECUTIVE --ETC(U)
AUG 77 F30602-76-C-0383
UNCLASSIFIED ITTG-TP-0002/L-7018-VOL-1 RADC-TR-77-270-VOL-1 NL

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RADC-TR-77-270, Volume I (of three)
Final Technical Report
August 1977

UNATTENDED/MINIMALLY ATTENDED RADAR STUDY
Executive Summary

ITT Gilfillan

A045543

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, New York 13441

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

19

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
18 RADC-TR-77-270 ~~, Vol I (of three)~~ - Vol-1

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
6 UNATTENDED/MINIMALLY ATTENDED RADAR STUDY. Volume I.
Executive Summary.

5. TYPE OF REPORT & PERIOD COVERED
9 Final Technical Report.

6. PERFORMING ORG. REPORT NUMBER
TP 0002/L 7018

7. AUTHOR(s)
Land Based Air Defense Systems Group

8. CONTRACT OR GRANT NUMBER(s)
15 F30602-76-C-0383

9. PERFORMING ORGANIZATION NAME AND ADDRESS
ITT Gilfillan
7821 Orion Avenue
Van Nuys CA 91409

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
63101F 17 01
16 E2330102

11. CONTROLLING OFFICE NAME AND ADDRESS
Rome Air Development Center (OCDE)
Griffiss AFB NY 13441

12. REPORT DATE
11 August 1977

13. NUMBER OF PAGES
5

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
Same
14 ITTG-TP-0002/L-7018-Vol-1

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
N/A

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited. 12 10p.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
Same

18. SUPPLEMENTARY NOTES
RADC Project Engineer:
Adrian S. Briggs (OCDE)
The effort reported here was sponsored by the Electronic Systems Division/XR, Hanscom Air Force Base MA 01731.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
UAR - Unattended Radar
MAR - Minimally Attended Radar
DEWLine
Life Cycle Cost
Surveillance
Reliability

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This executive summary presents an overview of a study of alternative radar design approaches that could be developed to optimally satisfy requirements for unattended and minimally attended radar operations. The requirements, detailed in the study statement of work, consist of two sets of nominal radar performance parameter goals; one set for the unattended radar (UAR) and a second for the minimally attended radar (MAR). Based on these requirements, alternative radar design approaches were synthesized for both UAR and MAR, and evaluated for reliability, life cycle cost (LCC), and performance. (cont'd)

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

388 599

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The radar designs recommended for UAR and MAR displayed the greatest potential for optimally satisfying all stated requirements. These designs are detailed in Volume II of the report. The UAR, a 60 nmi 2D radar, automatically outputs target track data that can be remoted to manned logistics nodes and/or ROCCs via narrowband communications links. It provides all altitude surveillance coverage of aircraft targets between 100 and 100,000 feet, and is configurable to be sufficiently reliable to guarantee, to a >90 percent confidence level, failure-free system operation for periods of time from three months to one year. The MAR, a 200 nmi 3D radar, also automatically outputs target track data to logistics nodes and/or ROCCs. It provides all altitude 3D coverage of aircraft targets between 100 and 100,000 feet, and is configurable to be sufficiently reliable to guarantee, to a >90 percent confidence level, failure-free system operation for periods of time from five days to 0.5 month.

Volume I provides an Executive Summary of the Unattended/Minimally Attended Radar Study. Volume II presents alternative approaches investigated and details the radar designs recommended. Volume III presents data estimating radar acquisition and Life Cycle Costs.

EVALUATION

The effort reported is one of three parallel study contracts performed under Project E233 by direction of ESD/XR. These reports identify alternative concepts and activity necessary to support the development of a short-range, unattended radar and a long-range minimally attended radar. The short-range radar is being viewed for application in DEW Line to replace the AN/FPS-19 and the long-range radar is being viewed for application by the Alaskan Air Command to replace the AN/FPS-93. These studies provide the assurance that current technology can support the development of unattended/minimally attended radars that offer improved performance and can significantly reduce operating and maintenance costs.

These efforts were performed in accordance with 1978-1982 TPO III, Thrust C Advanced Sensor Technology. The results will be used by ESD to develop system acquisition strategy for SEEK FROST (Project 2448), PE 12412F. It also provides supplemental data supporting SEEK IGLOO (Project 968H), PE 12325F.

Adrian S. Briggs

ADRIAN S. BRIGGS
Project Engineer

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EXECUTIVE SUMMARY

Introduction

This volume presents an overview/summary of the findings of a five-month study of Unattended/Minimally Attended Radars (UAR/MAR) conducted by ITT Gilfillan for RADC under Contract No. F30602-76-C-0383.

The study was directed to evaluate alternative radar designs that can potentially provide unattended/minimally attended radar operations at low cost. Consequently, a major study objective was to identify R&D activities that should be undertaken to support the development of UARs/MARs that could, in the 1980's, provide the Air Force with increased long term, cost effective systems.

Two types of radars were addressed: a short range, 60 nmi, 2D radar designed for long term (three months to one year) unattended operations in remote areas (e.g., the Arctic); and a medium range 150-200 nmi, 3D radar designed for cost effective minimally attended operations.

Unattended Radar (UAR)

The UAR design must achieve very high operational reliability at low Life Cycle Cost (LCC) and provide automatic target detection/tracking with narrowband remoting of surveillance data on aircraft at low to high altitudes.

To best provide all altitude coverage, and to automatically output surveillance data compatible with narrowband links, the UAR operating frequency selection is L-band (1215-1400 MHz).

The reliability required for unattended operations (system MTBF on the order of 10^4 hours) can be achieved if full advantage is taken of high reliability components and modular redundancy. Cost, of course, is an ever present consideration. Up to a point, increasing the reliability of a system decreases its LCC. Beyond that point, improvements in system reliability, obtained for example, through the employment of massive redundancy, seriously escalates system LCC. Reliability -- LCC optimization is consequently of paramount importance. Several alternative designs were considered for the UAR. The recommended approach, shown in Figure 1, provides a 2D surveillance performance capability that is compatible with the stated goals and can be configured to provide unattended failure-free operations (≥90 percent confidence level) for periods of time from three months to one year. The average unit production cost (based on a quantity of 80 systems) is estimated to be

$454,821 for a 3-month, failure-free system
$480,921 for a 6-month, failure-free system
$527,403 for a 12-month, failure-free system.

The three month failure-free system has a 20-year life cycle cost (acquisition plus support) of approximately $81M. The LCCs for the 6-month and 12-month failure-free systems are higher than the 3-month system.

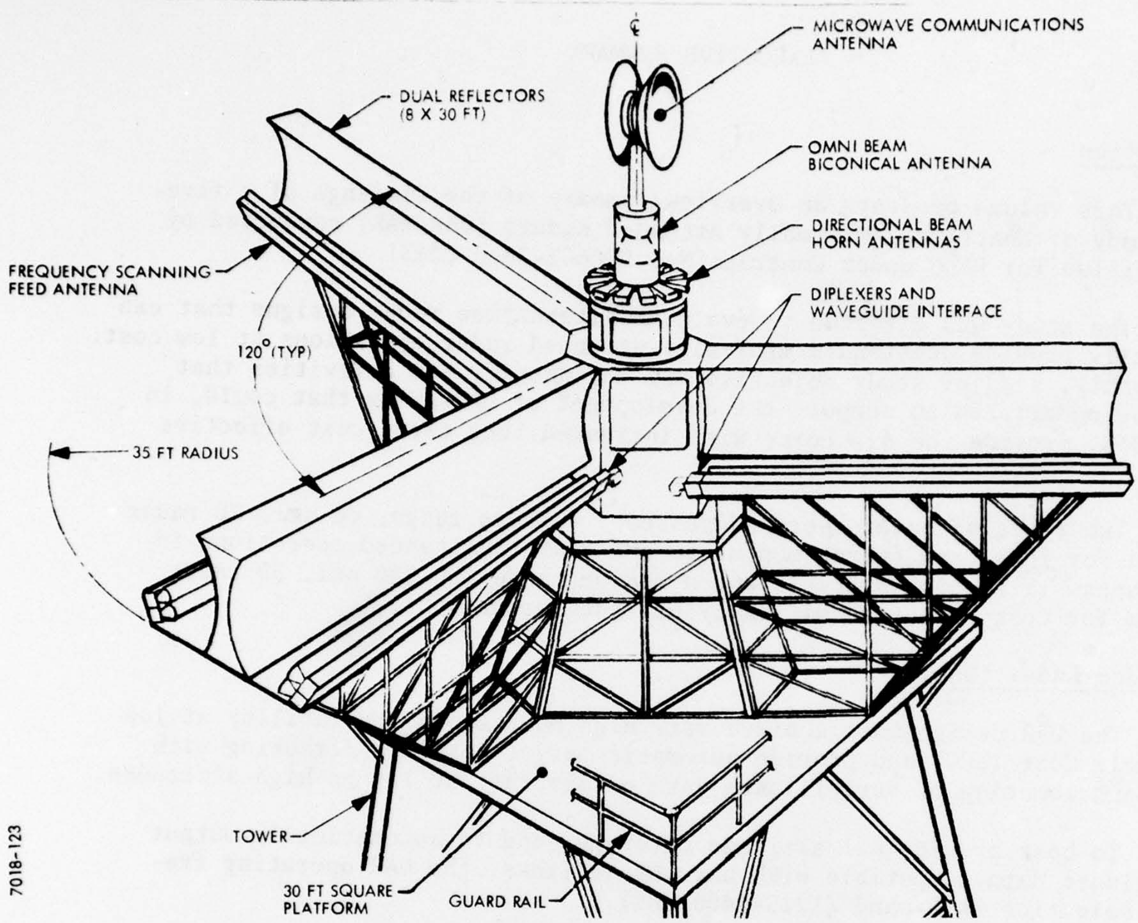

Figure 1. UAR Conceptual Sketch (Tri-Form Arrangement)

Other pertinent UAR performance parameters are listed below:

UAR Parameters

Antenna Type	6 array faces, frequency scanned in azimuth: 1 elevation TX beam and 1 elevation RX beam formed in either of two positions to cover a lower or upper EL sector
Frame Time	360^{0} azimuth in six seconds
Operating Frequency Band	1215-1400 MHz
Prime Power Required	518.5 watts dc
RF Power Output	2 kW peak, 100 watts average
Probability of Detection	0.9 for $1m^2$ SWI TGT at 30 nmi
System MTBF	88,760 hours (0.906 probability of failure-free system operation for 1.0 year)

Minimally Attended Radar (MAR)

The MAR requirements are sufficiently different from the UAR, e.g., more prime power available, less reliability required, to permit selection of less restrictive design approaches. Since low and high altitude surveillance and automatic data remoting, however, are common requirements to both UAR and MAR, L-band is also specified as the optimum operating frequency band for the MAR.

The lower system reliability required for the MAR is satisfied by a system that employs a single mechanically rotated antenna array and a single-stage tube type (TWT) transmitter.

The recommended MAR design approach, shown in Figure 2, provides a 3D surveillance capability that is compatible with stated goals and can be made sufficiently reliable to provide failure-free operations (≥90 percent confidence level) for periods of time from 5 days to 0.5 month.

The attainment of higher radar reliability (greater than 0.5 months) would necessitate the investigation of different design approaches, e.g., solid state transmitters. Time, however, did not permit the development of these approaches for the MAR.

The average unit production cost (based on a quantity of 20) estimated for the MAR is as follows:

$2,110K for a 5 day failure-free system
$2,640K for a 0.5 month failure-free system

Other pertinent MAR performance parameters are listed in the table below:

MAR Parameters

Antenna Type	Single array face, mechanical rotation in azimuth 1 elevation TX beam and six simultaneous elevation RX beams phase scanned between a lower and upper El sector
Frame Time	360° azimuth in 12 seconds
Operating Frequency Band	1215-1400 MHz
Prime Power Required	60 kw ac
RF Power Output	200 kw peak, 5 kw average
Probability of Detection	0.9 for $1m^2$ SWI TGT at 150 nmi
System MTBF	4275 hours (0.918 probability of failure-free system operation for 0.5 month).

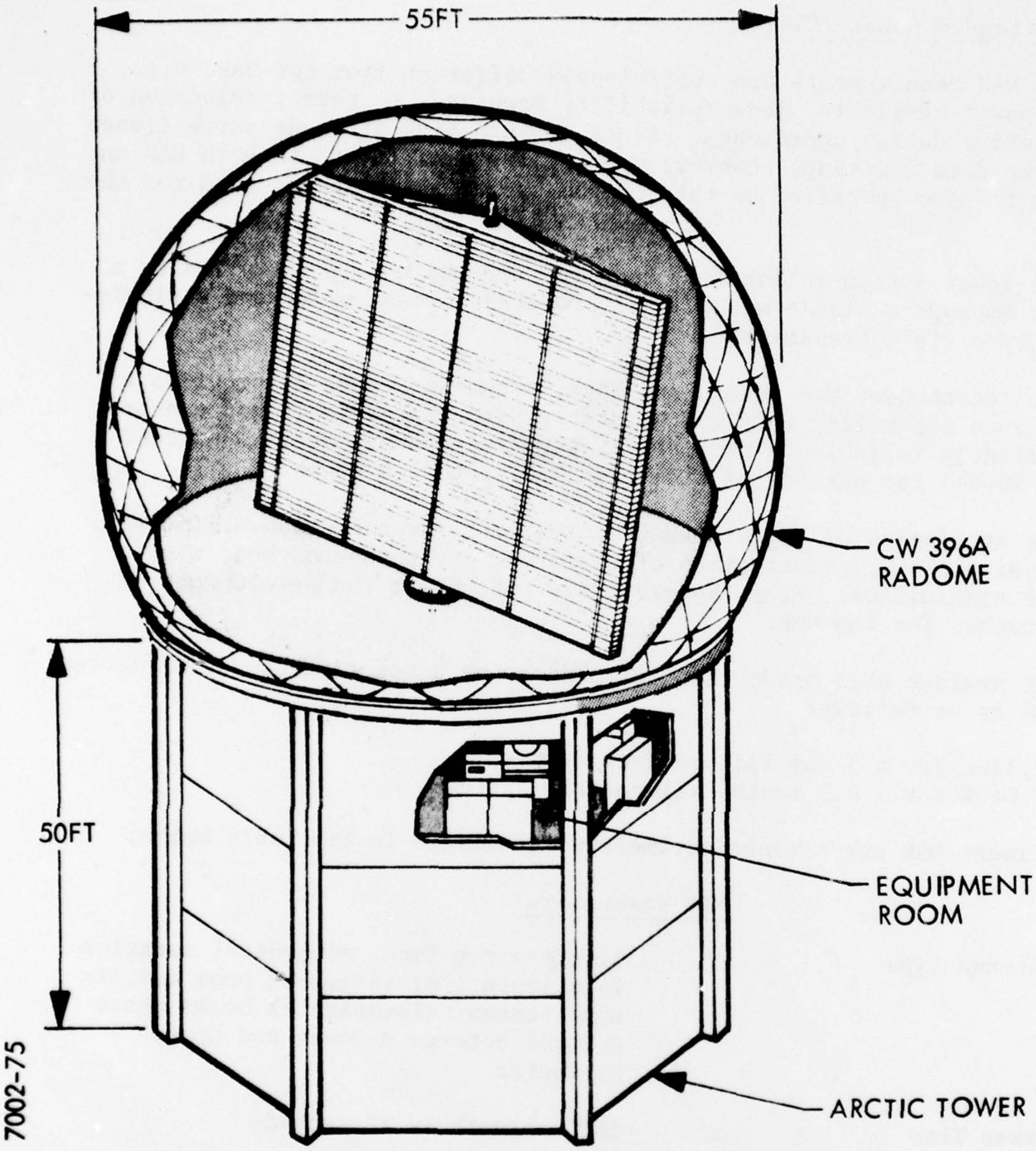

Figure 2. Artists Concept MAR

Recommended R & D

To support the early definition and development of unattended and minimally attended radars, ITT Gilfillan recommends: 1) that the UAR/MAR study be continued so that systems' requirements can be optimized prior to USAF generation of system specifications; 2) that those system elements, e.g., M/N solid state transmitter and M/N digital processor, that have shown the greatest potential for reducing overall system technical risk and cost, be developed immediately.

In keeping with the above recommendations, ITT Gilfillan has structured a comprehensive company funded program (requirements optimization studies and hardware developments) that is in direct support of the UAR/MAR program objectives.

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Printed by
United States Air Force
Hanscom AFB, Mass. 01731